

**Navy Theater-Wide Defense  
AEGIS LEAP Intercept (ALI)/STANDARD Missile Three (SM-3)  
Flight Test Program Overview**

by Scott D. Robinson  
STANDARD Missile Company  
McLean, VA

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**Navy Theater-Wide Defense**

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## **AEGIS LEAP Intercept (ALI)/STANDARD Missile Three (SM-3) Flight Test Program Overview**

by Scott D. Robinson  
Senior Test and Evaluation Engineer  
STANDARD Missile Company  
McLean, VA

### **Background**

The Navy Theater-Wide (NTW) program was established to investigate the Navy's tremendous and unique potential to provide the U.S. with a crucial, rapidly deployable, highly mobile, and readily sustainable long-range Theater Ballistic Missile Defense (TBMD) capability. To minimize the development risk inherent in this extremely challenging endeavor, the program was divided into several evolutionary phases. The initial phases of the program include a series of technology development and flight test demonstration activities involving the integration of advanced Ballistic Missile Defense (BMD) interceptor technologies with existing Navy Anti-Air Warfare (AAW) systems. The flight tests are designed to demonstrate the feasibility and the utility of the NTW concept before formal commitment to a Major Defense Acquisition Program (MDAP).

The first phase of the NTW flight test program, the Terrier Lightweight ExoAtmospheric Projectile (LEAP) Technology Demonstration Program, involved integration of several Ballistic Missile Defense Organization (BMDO) developed LEAP technologies with the

Navy's SM-2 Block II/III Extended Range STANDARD Missiles and the Terrier shipboard combat system. This project culminated in a series of four increasingly complex at-sea flight tests of various versions of the modified Terrier LEAP missile. It was completed in March of 1995. Terrier LEAP successfully demonstrated several important NTW features: 1) the infusion of advanced BMDO interceptor technologies into existing Navy STANDARD Missile systems; 2) the incorporation of several critical TBMD enhancements to the long-range SM-2; and 3) the potential of the integrated STANDARD Missile LEAP technologies to perform the theater-wide or "upper-tier" portion of TBMD.

The encouraging results of the Terrier LEAP program led to the formal initiation of the next phase of the NTW flight test program, the AEGIS LEAP Intercept (ALI) program. This project is incorporating enhanced versions of the LEAP and STANDARD Missile interceptor technologies demonstrated during Terrier LEAP into the newly developed SM-2 Block IV Extended Range missile and the associated Advanced Electronic Guided Interceptor System (AEGIS) Weapon System

(AWS). The objective of this phase of the NTW program is to demonstrate intercept of a tactical ballistic missile (TBM)-representative target with a kinetic warhead outside of the atmosphere -- an objective essential to the progress of the NTW program. To streamline the development process, the ALI program is leveraging heavily off of not only the Terrier LEAP interceptor technologies, but also the modifications made to the shipboard AWS for the Navy Area (lower-tier) TBMD program as well as the missile and Vertical Launching System (VLS) technology enhancements demonstrated during the SM-2 Block IV development and operational testing (DT/OT).

Recent world events have continued to highlight the necessity of a long-range Naval TBMD capability. The urgent need for NTW technology coupled with the tremendous potential of the STANDARD Missile LEAP interceptor has recently led BMDO to designate the NTW program as a "Core BMD Program" as recommended during the President's Bottom-Up Review of 1993. Moreover, in a letter dated December 3, 1996, the Under Secretary of Defense reemphasized the importance of the NTW program and selected it as "a pre-MDAP program, an effort which may eventually become a MDAP . . . ." He also directed that the ALI program ensure it is prepared to enter into the acquisition life-cycle at an appropriate future date. Therefore, program planning is under way to comply with this direction. A successful ALI program could lead to a User Operational Evaluation System (UOES) contingency

TBMD capability and, potentially, to a follow-on tactical capability shortly after the turn of the century.

### **Program Description**

#### **Missile Description:**

The ALI program, with its newly designated "SM-3" missile, evolves the two stage endoatmospheric SM-2 Block IV AAW missile into a four stage, exoatmospheric, "hit-to-kill" TBM interceptor. Figure 1. provides an overview of the SM-3 round and its major sub-assemblies.

The Block IV propulsion train [MK-72 booster, MK-104 Dual Thrust Rocket Motor (DTRM), and Steering Control Section (SCS)] remains unchanged. However, forward of the DTRM are several new and/or repackaged components. Attached to the forward end of the DTRM is a newly developed Staging Assembly (SA). This assembly includes the new second stage batteries (two 160V and one 28 V), the second stage Power Changeover Unit (PCU), and a third stage separation system that is evolved from and very similar to the Terrier LEAP system. The forward end of the SA is attached to the third stage using four explosive bolts. When the explosive bolts are fired (via transfer lines attached to a common, redundantly actuated ordnance manifold) they fracture. Then, a stack of Belleville washer springs detaches the third stage from the second and provides a small relative separation impulse. This

assembly remains with the DTRM upon separation. At the aft end of the third

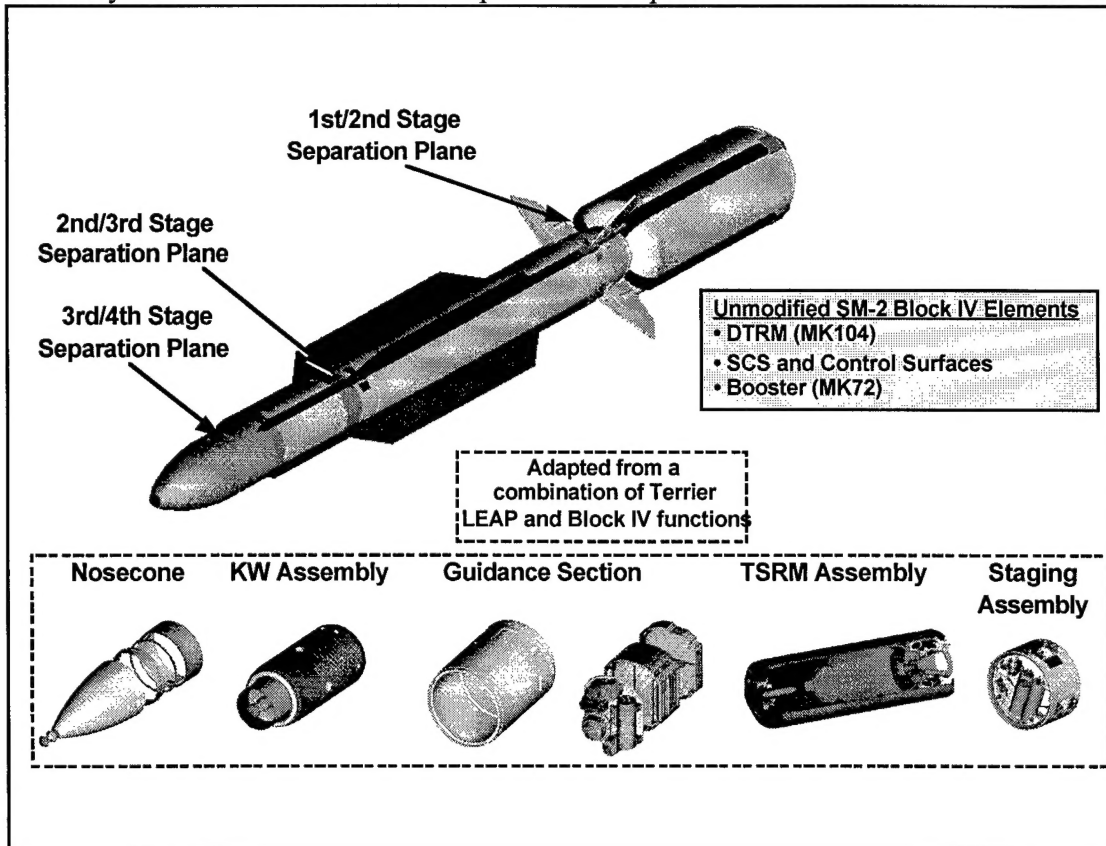


Figure 1. SM-3 Round Overview

stage and replacing the Block IV explosive warhead section is a new Third Stage Rocket Motor (TSRM) assembly. The TSRM is evolved from the BMDO developed Terrier LEAP Advanced Solid Axial Stage (ASAS) motor. It incorporates a similar graphite-epoxy composite case-on-propellant design, consumable igniters, and approximately 205 lbs of proven TP-H-3340 Aluminum/Ammonium Perchlorate (Al/AP) propellant with a Hydroxyl Terminated PolyButadiene (HTPB) binder. However, to improve energy management flexibility, the TSRM now includes two separate propellant grains (separated by a Kevlar-filled EPDM

rubber thermal barrier integrated as part of the case liner) that provide two independent pulses on command. This controllable, multi-pulse design has been demonstrated during previous Thiokol research and development activities. Additionally, the TSRM diameter and length have been increased to allow for greater propellant mass and increased delivered impulse. With the increase in motor external diameter to that of the DTRM & SA (13.5 inches), the TSRM is no longer mounted inside of a metal shroud. Instead, the 38 inch long TSRM case and end rings now serve as a structural element of the SM-3 airframe. Therefore, cork insulation will be added

to the exterior of the composite case to protect it during ascent. Also, four cable strakes have been extended forward of the dorsal fin assemblies to allow for cable routing from the avionics section, along the TSRM case, to the aft end of the TSRM and the lower stages. To accommodate these strakes and enable smooth separation of the second and third stages, the forward edge of the Block IV dorsal fin design has been modified slightly by the addition of a separation joint.

The aft end of the TSRM assembly, very similar to Terrier LEAP, includes a silica-phenolic, omniaxis, Thrust Vector Controlled (TVC), flexseal nozzle; an electro-mechanical thrust vector actuation (TVA) system; and a densely packaged, hybrid (hot and cold gas) attitude control system (ACS). The ACS includes four solid propellant hot gas generators (2000° F flame temperature) for fast-response, high-impulse pointing maneuvers; and a torroidal cold gas (10,000 psi GN<sub>2</sub>) tank for lower-impulse maneuvers, roll control, and station keeping. These systems provide sustained control of the third stage at high altitudes after separation from the second stage. On the forward end of the TSRM are two motor safe and arm (S&A) devices, one mounted in the motor bore for pulse one, and one on the dome for pulse two. Also on the forward dome is a thrust termination system composed of a flexible linear shaped charge (FLSC), two FTS S&As, and two explosive transfer assemblies (ETAs). The FTS design is unchanged from Terrier LEAP.

Forward of the TSRM is the modified SM-3 Guidance Section (GS). This section includes a SM-2 plate 3A communications transceiver; a redesigned and repackaged avionics assembly; a power plate; a silica-phenolic insulated, lightweight aluminum shroud; and the AEGIS Link, GPS, and telemetry antennas. Plate 3A retains the existing AEGIS Link capability and is unmodified from SM-2 Block IV. The avionics suite incorporates all of the Terrier LEAP guidance and control functions, including a Global Positioning System Aided Inertial Navigation System (GAINS), into ten circuit card assemblies (CCAs) housed in a lightweight structure. This assembly is shown in Figure 2. The avionics CCAs in order from front to rear are: a PCU/power regulator card, a telemeter card, a Flight Termination System (FTS) CCA, an encoder/decoder communications card, the GAINS receiver/processor CCA, an AEGIS Input/Output (I/O) card, a Stage 2 Control Computer (S2CC), a Stage 3 Control Computer (S3CC), an Electro-Explosive Device (EED) controller, and a TSRM controller.

All of these CCAs are connected to a parent board in a Virtual Memory Expandable (VME) backplane chassis design. The EED controller design has been improved from Terrier and replaces all squib switches with Field Effect Transistors (FETs). Also, the large number of single-shot EEDs used in the Terrier LEAP design (49) has been reduced to 38.

Attached to the forward end of the avionics suite is the "power plate." The power plate includes the remaining oddly

shaped items such as the third stage, FTS, and TSRM batteries; the ring-laser gyroscope Inertial

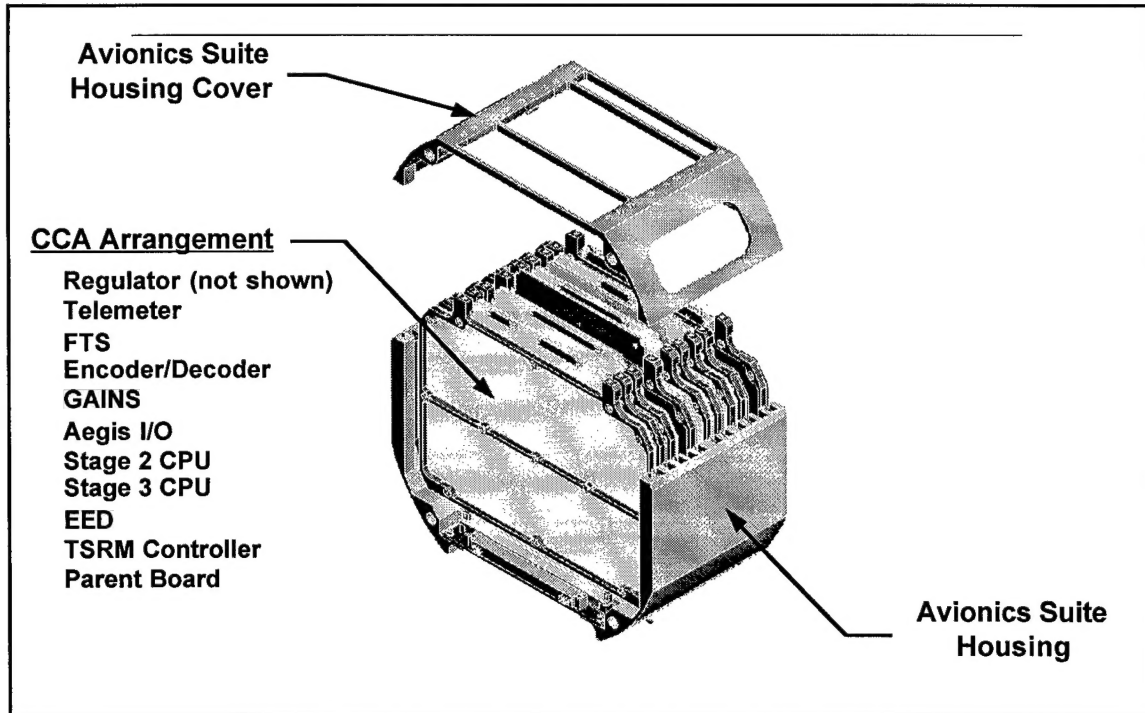


Figure 2. Avionics Suite Layout

Measurement Unit (IMU); the range required Ultra High Frequency (UHF) FTS transceivers (2); the telemetry transmitter; and the G-switch. This plate also serves as a thermal sink for several of the high energy electronic components. Closely mounted in Duroid on the exterior of the cylindrical shroud are the redesigned, multi-element, wrap-around Telemetry, GPS and FTS antennas, and the two unchanged AEGIS Link patch antennas.

Also included in the guidance section is a fiber optic cable external interface to the VLS system. This "hot start" interface allows VLS to provide the missile

GAINS system with required initialization information (GPS satellite almanac and ephemeris data) just prior to launch. The data is transmitted via a flexible thin strand of shielded fiber optic cable which breaks at the missile skin upon egress. The remainder of the strand is retained in the canister.

Attached to the forward edge of the GS shroud is the separable nosecone assembly. This system is also very similar to the Terrier design, yet somewhat simplified, improved, and reduced in weight. The nosecone assembly consists of a glass-phenolic insulated aluminum adapter ring; a

titanium end ring; an insulated, filament wound composite (graphite bismaleamide) tangent ogive body; and a blunted titanium nose tip. The nosecone shape allows for greater useable internal volume than Block IV and is the same as that flown during Terrier LEAP. The adapter ring is fixed to the GS shroud via a radial screw joint and remains with the guidance section after separation of the nosecone. The interior of the nosecone is coated with conductive electroless nickel to maintain electromagnetic shielding and help reduce radiative heat transfer to the kinetic warhead.

The nosecone end ring is attached to the adapter ring via a rivet joint (60 circumferential aluminum rivets). Compressed between the end ring and adapter is a flattened, sealed tube of expanding, shielded, mild detonating chord (XSMDC). When ignited, via an improved "dual-sided" manifold initiator system, the annular steel ring of XSMDC expands, drives the nosecone forward, shears the rivets, and ejects the

nosecone. This system no longer involves the interior "sliding sleeve" of the Terrier design and should enable more consistent, reproducible tip-off and velocity results. For the ALI missions, the nosecone will be ejected between the two TSRM pulses. This timing will allow maximum protection of the KW from aerothermal heating during ascent.

The final remaining assembly in the SM-3 missile is the improved Kinetic Warhead (KW) or fourth stage (Figure 3.). This critical element, evolved from LEAP kinetic kill vehicle technology, is essentially a missile within a missile. Its small size and weight (approximately 22" long by 10" diameter, and 37 lbs) enable it to fit within the nosecone assembly (approximately 12.5" base diameter by 25" long) which contributes to maximized missile burnout velocity and, therefore, improved kinematic range and lethality.

The KW is composed of essentially four major subassemblies: a seeker assembly



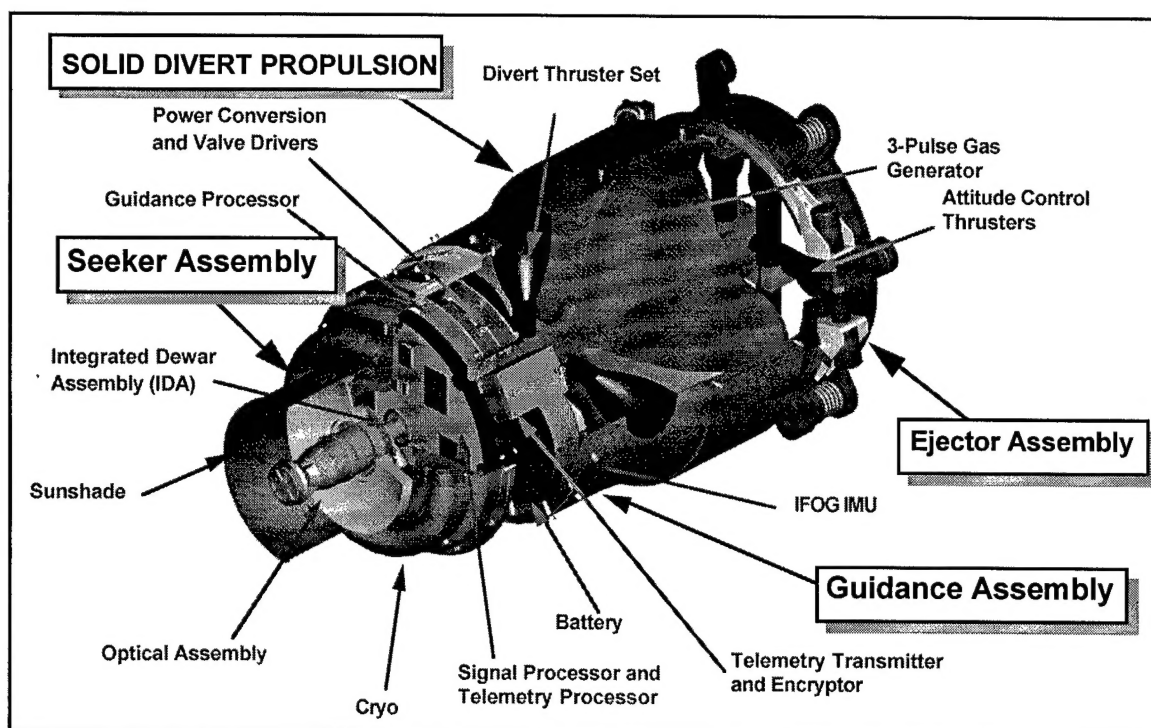


Figure 3. Partial Cut-Away of Kinetic Warhead with Ejector Mechanism

consisting of a cryogenically cooled, body-fixed, staring, Wide Field-of-View (WFOV), Long-Wave InfraRed (LWIR) sensor and its associated signal processor; a guidance assembly which includes a data processor, an interferometric fiber-optic gyroscope IMU, a thermal battery, and a telemetry transmitter system; a Solid Divert and Attitude Control System (SDACS) propulsion assembly; and an interface and ejector mechanism. The interface and ejector mechanism provides both mechanical and electrical interfaces with the third stage as well as shock isolation and separation of the KW from the third stage.

Once ejected from the third stage, the KW activates its SDACS. It then points at the known position of the TBM target, acquires it with its passive IR

seeker, autonomously homes on the target using its onboard guidance system and SDACS lateral maneuvering system. The KW destroys the target by force of impact. Unlike the Terrier LEAP kinetic warheads, the SM-3 KW will not include any liquid propellants. The three-grain, two pulse-level SDACS system (which was developed by BMDO over the past 10 years) uses approximately 10 lbs of HTPB/AP propellant (3700° F flame temperature). It provides a more VLS compatible, less toxic, and less sensitive propulsion capability than its liquid counterparts.

Finally, because of the added length of the SM-3 missile (Block IV + 4"), a new forward cover for the VLS MK-21 canister is being designed. The dome-shaped cover will accommodate the longer SM-3 (and future versions of



STANDARD Missile) with approximately one inch of margin. This new frangible cover, created from syntactic foam with a rubber exterior surface coating, will fit within the existing space under the VLS cell hatch. Encanistered missile length and weight increases will also require a few minor modifications to storage and handling equipment as well.

Because of the GPS initialization and interface requirements of SM-3, a VLS GPS Integrator (VGI) system is being developed to provide the missile GAINS with the necessary data. A fiber-optic distribution system, including the cables, connectors, and junction boxes, connects the VGI to the missile. As with all missile hardware and software, all modifications to the VLS and canister

systems are undergoing a comprehensive series of design validation tests in conjunction with the extensive in-process integration and check-out tests.

### Mission Descriptions:

Although detailed flight test plans are still evolving, the ALI flight test program currently consists of an incremental series of seven flights of various configurations of the SM-3 missile, each increasing in complexity. Figure 4. shows how these flights are intended to progressively retire the risks for each phase of SM-3 flight.

Primarily because of the large kinematic footprints generated by the high altitude, high velocity SM-3 missile

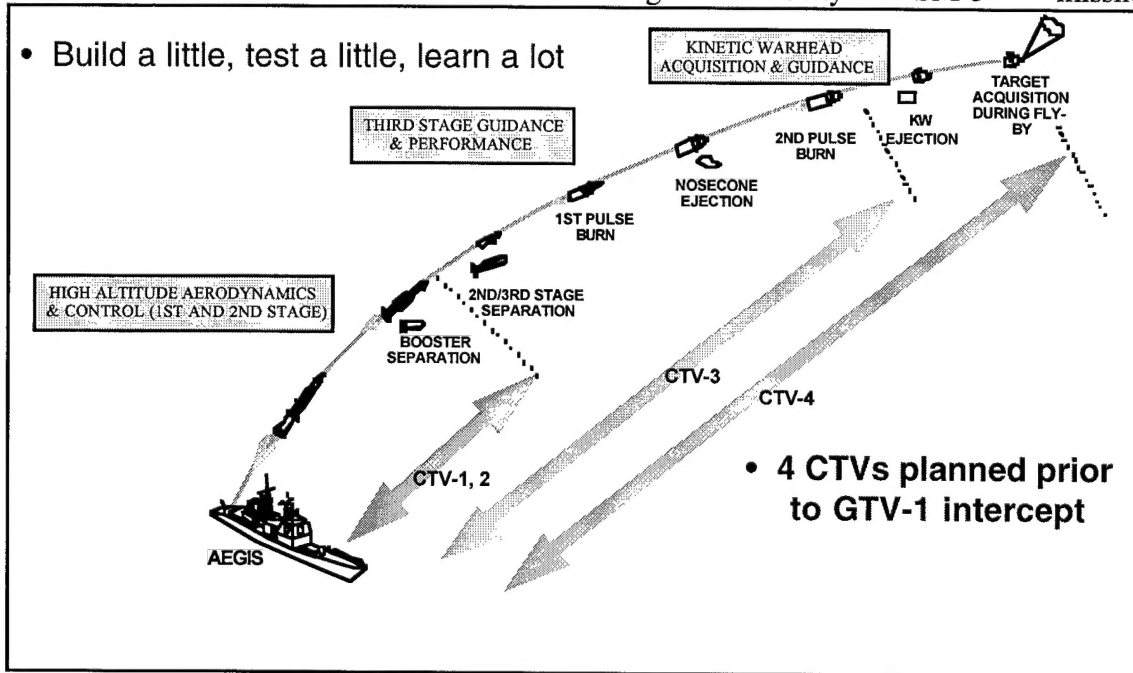


Figure 4. Incremental CTV Flight Testing Reduces Risk for Intercept Missions

configurations, all of the SM-3 missions will be performed at sea at the Navy's Pacific Missile Range Facility (PMRF) sea test range. The first three SM-3 flight tests do not involve a physical target and are designated Control Test Vehicle (CTV) missions. Of these three CTVs, the first one (CTV-1) does not include the new separable third stage and involves essentially a modified SM-2 Block IV missile. The second mission, CTV-2, will more closely replicate the SM-3 airframe shape and mass properties, but will again consist of only two stages including the Blk IV guidance system with high altitude modifications. The next two missions (CTVs -3 and -4) will include the new third stage with a live TSRM, the new SM-3 guidance section, and the ejectable nosecone and KW. The three remaining missions are Guided Test Vehicles (GTVs -1 through -3). Each of these involves a "full-up"

SM-3 missile and will demonstrate intercept of the TBM-representative target in a slightly differing scenario. Figure 5. shows the GTV-1 concept. An option for a fourth GTV mission has also been established. The GTV-1 mission will serve as the baseline SM-3 mission. Each of the CTV missions will attempt to emulate increasing elements of this flight.

Prior to the first GTV, a target demonstration will be performed. This Target Test Vehicle mission (TTV-1) will demonstrate suitable performance of the Aries-based TBM target prior to its involvement in an intercept mission. The target demonstration mission will also enable verification of various AWS tracking and targeting functions as well as a rehearsal of the critical intercept mission timeline and range operations. It may be performed in conjunction with

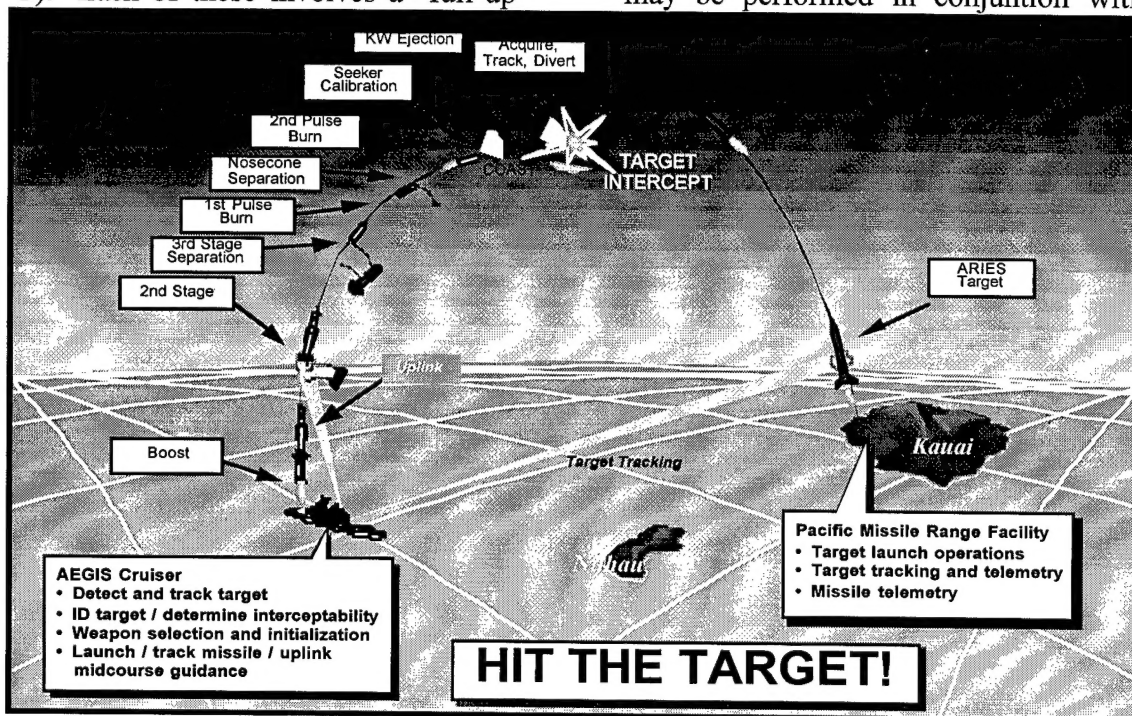


Figure 5. Initial Intercept Scenario at PMRF

the CTV-4 missile flight test. The target for all GTV missions will be of similar design and performance to that certified for and used during the Terrier tests.

#### CTV-1:

The purpose of the CTV-1 flight demonstration will be to: verify 2nd stage autopilot design at altitudes up to the GTV-1 2nd-3rd stage separation point; collect data up to the outer edge of the autopilot design envelope; and exercise the test range and support functions as a precursor to SM-3 flights to follow. The CTV-1 mission will emulate, as closely as possible, the GTV-1 trajectory up through the 2nd-3rd stage separation point. Figure 6. shows the CTV-1 mission concept.

During conduct of CTV-1, the ship will be positioned to replicate the over-the-horizon geometry of the GTV-1 mission. Because of the large debris patterns created by destruction of the warhead at high altitudes, the missile will be launched from a position approximately 300 km due north of the test range on a bearing of about 330 degrees. This geometry minimizes potential interference with shipping and air traffic lanes. The CTV-1 missile will utilize a SM-2 Block IV Full-Scale Engineering Development (FSED) hardware baseline with minor modifications. The FSED hardware has been successfully qualified and was flown from an AEGIS ship in July and October of 1994. The only hardware upgrade from the FSED baseline for CTV-1 will involve replacement of the 16 Mhz Digital

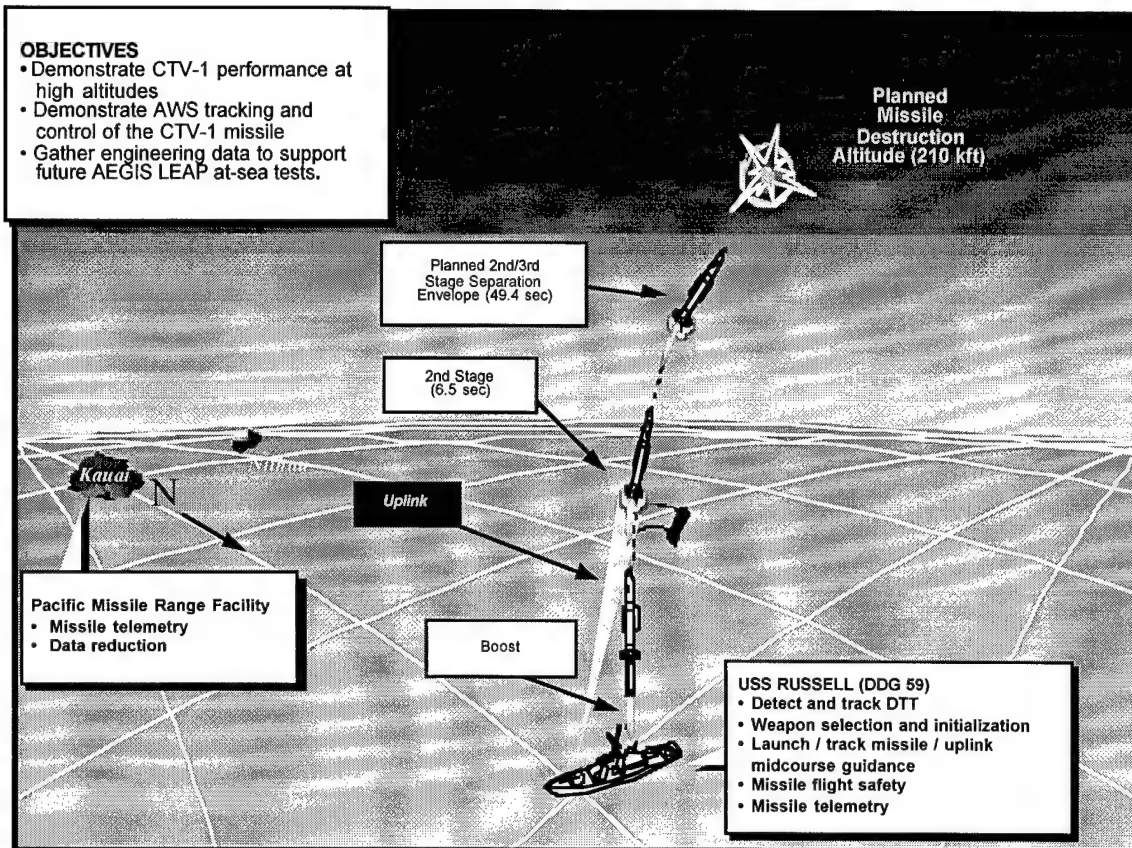


Figure 6. CTV-1 Scenario at PMRF

Signal Processor (DSP) with the 24 Mhz DSP of the Production Test Round/Low Rate Initial Production (PTR/LRIP) missile including the support hardware required to incorporate this DSP into the FSED GS. These modifications involve replacing the FSED GS flex cable with the PTR flex, and adding hardwires for the seeker head ground and the DSP regulator 18 Vdc power. Modifications to the FSED autopilot software (expanded high altitude atmospheric tables and gain changes), will be required for the CTV-1 high altitude flight. To handle the increased processing requirements, additional DSP memory is desired to reduce overflow risk. Incorporation of the PTR/LRIP 24 Mhz

DSP will accomplish this goal. These hardware modifications were incorporated into the SM-2 Block IVA Risk Reduction Flight Demonstration (RRFD) Demonstration Test Round (DTR) and have been successfully qualified for flight. The DTR-1A missile successfully intercepted a Lance TBM target at White Sands Missile Range (WSMR) on January 24, 1997.

The AWS modifications for CTV-1 will include adding a simulated, fixed, high altitude target for the CTV-1 missile to fly toward, and incorporating a modified heading command guidance scheme for midcourse flight. Since the missile does not include the new exoatmospheric third

and fourth stages, it will be command destroyed at an altitude just above 200,000 ft before aerodynamic control is lost. This approach assures the Missile Flight Safety Officer positive control of missile flight and debris patterns at all times.

The proven, comprehensive SM-2 Block IV ground testing philosophy and approach will be maintained for the CTV-1 mission. Autopilot hardware and software design validation will be performed via Hardware-in-the-Loop (HIL) performance evaluation, AEGIS Combat System Engineering Development Site (CSEDS) testing, Johns Hopkins University Applied Physics Laboratory's Guidance System Emulation Laboratory (GSEL), and shipboard integration testing. These activities will enable concurrent evaluation of AWS software and missile-to-AWS interaction. The CTV-1 configuration is both flight and FTS qualified based on the Block IV FSED, PTR, and Block IVA RRFD programs. FTS hardware will remain unchanged. The mission is currently scheduled for the fourth quarter of calendar year (CY) 1997.

#### CTV-2:

The main impetus behind the CTV-2 flight test is to build on the data collected from the CTV-1 flight in a timely and incremental manner to reduce risk for the first "full-up" SM-3 shot (CTV-3). The proposed CTV-2 missile incorporates a modified Block IV airframe (aerodynamically similar in shape and

mass properties to the final SM-3 demonstration configuration) instrumented to provide valuable information regarding aerodynamic and aerothermal loads as well as flight control system characteristics. The configuration will include the new SM-3 nosecone shape, an additional four inch extension of the airframe forward of the GS, added weight, and mock third stage cable strakes to more closely replicate the SM-3 design. Current plans do not include ejection of the nosecone or KW.

The flight profile proposed for CTV-2 is very similar to CTV-1 within the constraints of the airframe modifications. This intention means that both missions will traverse similar stage 1 and stage 2 trajectories to those planned for GTV-1. This approach has the three-fold purpose of keeping the AWS modifications to a minimum between flights, providing a direct comparison of airframe performance between Block IV and SM-3, and providing another rehearsal opportunity for critical range operations and safety functions prior to flight of the "full-up" SM-3 design.

The proposed baseline missile hardware changes from CTV-1 are as follows: 1) the radome is replaced with the SM-3 nosecone; 2) a 4.5 inch long adaptor ring is added between the nosecone and guidance section (provides proper total missile length and greater packaging space); 3) some or all of the seeker head assembly is replaced with a KW thermal mass equivalent; 4) sensors (thermal, pressure, vibration, shock, and acceleration) are added to collect environmental data; 5) TSRM strakes are

added to the existing Block IV dorsal leading edges; 6) an environmental telemetry package (AN/DKT-71S) is installed to transmit data from 4), and 7) a UHF antenna and FTS receiver are added to the missile. The FTS antenna and receiver will enable verification of the ability to perform pre-launch end-to-end tests of the range required UHF independent FTS as well as check-out of the in-flight communications between this system and the range. To perform the pre-launch FTS tests, the VLS system and canister will be modified to enable receipt of the FTS signals from the range (via a relay aircraft) and retransmission into the canister to missile. Part of the purpose of the UHF tests will be to checkout the reliability of the UHF signal relays that are required because of the great (over-the-horizon) distances between the range and the ship.

The proposed missile software modifications include CTV-1-like changes to the autopilot computer program and accommodations for the environmental telemetry functions. The autopilot structural filter and gain changes (necessitated by the added missile mass and shifted center-of-gravity) are a direct precursor to those needed for the SM-3 vehicle. The CTV-2 mission is currently proposed for the fourth quarter of CY 98.

#### CTV-3:

The primary purpose of the CTV-3 flight is to provide an initial demonstration of the new third stage. CTV-3 is currently envisioned as a "full-

up" SM-3 round with the exception that the KW may not include a live propulsion system. Instead, the missile will incorporate an ejectable "smart mock-up" KW. As a minimum, the smart mock-up will include a live LWIR seeker, an IMU, a signal and data processor, a thermal battery, and a telemetry transmitter system. The CTV-3 missile will be launched from the GTV-1 launch position and fly the complete SM-3 trajectory through KW ejection. After ejection the KW may acquire an existing IR target such as a satellite, star or other celestial body. If independent KW pointing and/or maneuvering is identified as a requirement, the KW may incorporate a live SDACS. This mission will demonstrate all elements of the GTV-1 mission (including handover of targeting information from AWS to the third stage to the KW) except KW terminal homing. CTV-3 is proposed for the second quarter of CY 99.

Because of the high accuracy required for KW delivery, the TSRM will be controlled using a Burn-out Reference Guidance (BRG) scheme. This guidance method was demonstrated during Terrier LEAP. Once the second stage is separated, the third stage no longer uses AEGIS guidance commands. Instead, it accepts information on target state from the AWS and couples it with onboard information about its own state (GPS and/or inertial) and the burn conditions of the TSRM motor. It uses this data to compute the optimum trajectory of the third stage for target intercept, then translates it into gimbal commands for the TSRM nozzle. This method rapidly



and continually fine tunes the TSRM trajectory during motor burns and reduces delivery errors introduced by AWS and missile misalignments, biases, and motor uncertainties.

#### CTV-4:

CTV-4 is planned as a complete rehearsal of GTV-1 with a "full-up" SM-3 missile. The mission currently involves a simulated target, potentially from pre-recorded tapes of the TTV-1 mission. A live target "fly-by" in conjunction with the target demonstration flight is also under consideration.

#### GTV-1:

GTV-1 involves launch of the Aries target on a northwest trajectory (approximately 330 degrees azimuth) from the Kauai Test Facility (KTF) at Barking Sands, Hawaii. The target presentation and trajectory are expected to be similar to the Terrier LEAP FTV-3 and -4 missions with apogee near 325 km and down-range splash point just short of 500 km. The target will maintain a near zero angle of attack. The AEGIS test ship, located approximately 350 km west of Kauai, will acquire the target using its AN/SPY-1 radar, develop a track, compute an intercept trajectory solution, and initialize the GTV-1 missile. The missile will then perform a rapid Built-in-Test (BIT) of its systems. Upon successful completion of BIT, the missile will be launched (about eight minutes after target launch), perform a

pitchover maneuver to place it on the proper trajectory, then fly out on approximately a 15 degree azimuth toward the target. The KW will intercept the target on its descent leg, outside the earth's atmosphere, about 3 minutes after launch. The typical Block IV boost and pitchover guidance approach will be used. The target and missile ground path crossing angle is designed to be near 90 degrees (thereby improving the ability to engage both short and long targets), and intercept is expected between 150 and 240 km in altitude. The KW guidance algorithms will be designed to hit the centroid of the target body, thereby maximizing probability of intercept. Intercept debris is expected to land in open ocean well north and west of the Hawaiian islands. No target warhead, either inert or live, will be used.

Since the missile will be below the horizon of the range radars for the first 20 seconds or so of flight, use of a two Missile Flight Safety Officer (MFSO) concept is envisioned. A MFSO at PMRF will control the launch and fly-out of the target, and a Missile Flight Safety Analyst (MFSA) aboard ship (In conjunction with the Commanding Officer) will ensure positive control of the launch and flight of the missile until it breaks PMRF's horizon. Missile tracking information from the AWS and missile telemetry will be relayed from the ship to the MFSO on the beach via satellite for his use in determining the safe flight condition of the missile. After the missile breaks the radio horizon of PMRF, the MFSO will have access to both direct radiated telemetry and,



potentially, range radar skin tracking data. Since the SM-3 missile will not include a C-Band beacon for the range radars to acquire and track, AWS track and missile telemetry will assist in range radar acquisition and tracking, as necessary.

Also, as directed by the flight safety engineering activity for PMRF (NAWCWPNS Pt. Mugu), a new dual-redundant, independent UHF flight termination capability is being added to the SM-3 round. MFSO access to this

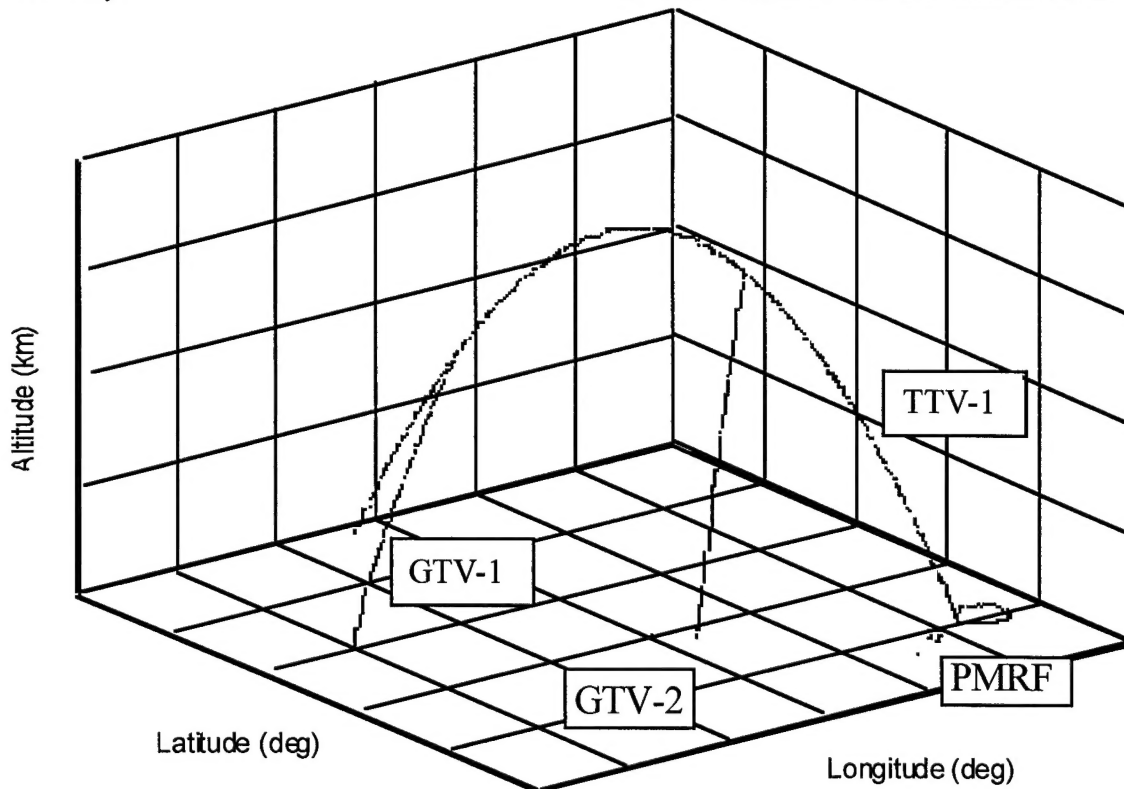


Figure 7. Intercept and Target Geometries at PMRF (Kauai, HI)

system in the early phases of flight requires relay of the UHF FTS signal from the beach to the missile until the missile breaks PMRF's radio horizon. The UHF relay function will likely be performed by a range aircraft. Status of the UHF FTS will be relayed back to the range control center in missile telemetry via satellite. The existing AWS S-band shipboard command destruct capability will be retained for use by the ship's commanding officer and as a backup to

the range certified UHF system. Several missile internal self-destruct features will also be included to ensure reliable, safe flight termination in the event of a hazardous or catastrophic missile failure. An FTS action will initiate stage 2 and 3 separation, thrust termination of the TSRM (via the dome cutter charge), and inhibition of any remaining EEDs. As with Block IV and Terrier LEAP, the G-switch will serve as the primary mechanical interlock ensuring a safe

separation distance between the missile and the ship before enabling FTS or upper stage propulsion activation. Performance of the GTV-1 mission is proposed for the last quarter of CY 99.

#### GTV-2:

GTV-2 is currently defined as an ascent phase intercept. The target will be launched on a trajectory similar to GTV-1. The ship will now be positioned approximately 150 km closer to shore with the intent of launching the GTV-2 missile on a 90 degree ground path crossing angle to intercept the target just prior to apogee. As flyout times are compressed, rapid AWS target acquisition and track as well as missile initialization and launch are much more critical. Figure 7. provides a comparison of the GTV-1 and -2 flight geometries and their relationships to the target fly-out at PMRF.

#### GTV-3:

GTV-3 is also defined as an ascent phase intercept. The intercept point for this mission is planned to occur very near the GTV-2 point; however, the ground path crossing angle is now 45 degrees. This means the ship is even closer to shore and the missile is performing what appears to be a "tail-chase" intercept as viewed from the earth. This mission is the most challenging of all three GTVs, both in terms of mission timelines and engagement geometries.

#### GTV-4:

GTV-4, and any subsequent missions that may be added, will enable the SM-3 team to vary any number (or none) of the mission parameters, as desired, in order to investigate sensitivities or anomalies that may have been discovered during the previous missions, or to further stress the capabilities of any part of the system. It also provides an opportunity to incorporate technology enhancements as they become available from concurrent technology development activities. The mission will be defined based upon data from the previous missions as well as the state of technology development in the latter phases of the program.

As stated above, the mission scenarios, especially those for the intercept missions, are currently undergoing trade studies. These trades include evaluations of technical performance, risk, and reliability as well as range safety, data collection, and operational considerations. Since demonstrating intercept of a TBM representative target is the primary objective of the ALI program, if intercept is not achieved on GTV-1, it will likely be repeated until intercept is achieved.

### **Concurrent Technology Development and Follow-On Activities**

In addition to the flight test activities, several interceptor technology investigation and enhancement efforts are also underway. For example, several technology risk reduction activities are in works to enhance future KW capabilities

as necessary. Improvements in areas such as divert performance and target detection, discrimination, and aimpoint selection capability are being investigated. In addition, the SM-3 propulsion contractors are participating in Navy sponsored insensitive munitions research and motor performance enhancement efforts which could lead to future improvements in STANDARD Missile. Further, a lethality evaluation and enhancement study and test program will ensure that future versions of SM-3 can appropriately address existing and evolving threats.

Per program office direction, the SM-3 is being designed such that at the end of the ALI program, a residual UOES capability will exist with minimal hardware modifications. Because of the controlled and streamlined nature of the ALI program, a tailored MIL-STD-2105B hazard assessment test program is being performed. These tests will help ensure safe operation of the SM-3 systems during integration, handling, shipping, and aboard ship for the limited and controlled ground and flight tests. Safety test plans include three tailored hazard tests of the new third and fourth stages: a forty foot drop test, a fast cook-off test, and a static firing of the propulsion systems. Each of these tests will be preceded by a 28 day temperature and humidity (T&H) test; transportation and shipboard vibration and launch shock tests; and a four day T&H test.

Finally, a complete series of Electromagnetic Environmental Effects (E<sup>3</sup>) analyses and tests, fault insertion

tests, battery qualification tests, FTS overstress tests, hazard analyses, safety assessments, and damage control/risk mitigation planning will be performed and documented as described in the comprehensive System Safety Program Plan (SSPP). Future activities will likely incorporate several of the above mentioned technology enhancements to improve the UOES and tactical capabilities. Prior to progression to UOES and tactical flight testing, completion of a comprehensive MIL-STD-2105 hazard test program is planned.